REMARKS/ARGUMENTS

[1] Remarks for Amendment to the Specification:

In the specification, the second paragraph in page 15 has been amended to add description for marked elements in element (50) depicted in Fig. 6(a).

[2] Remarks for Amendment to Drawings 4-7:

In amended Figs. 4, 5 and 7(b), the previously omitted element number (54) has been added and marked.

In amended Fig. 6(a), the previously omitted element number (54) has been added and marked and the element (68) has been marked.

[3] Remarks for Amendments to Claims 7 – 13:

"[ ]" is removed around the number of the Claims 7-13 so that the amended Claims 7-13 begin with numerical numbers.

In view of examiner's detailed action, the following corrections have been made to Claim 7: "separate by a gap" has been changed to <u>separated by a gap</u>; "along direction" has been replaced by <u>along a direction</u>, so that Claim 7 reads as:

7. An electrostatically actuated MEMS switch for microwave and millimeter wave signals with DC to RF isolation and a de-actuation device comprising:

- a first dielectric substrate having an input transmission line and an output transmission line deposited on a front surface of said first dielectric substrate, said

Amendment to the Drawings:

The attached three sheets of drawings include changes to Fig. 4-7. The first sheet, which includes Fig. 4-5, replaces the original sheet including Fig. 4-5. The second sheet, which includes Fig. 6(a) and 6(b), replaces the original sheet including Fig. 6(a) and 6(b). The third sheet, which includes Fig. 7(a) and 7(b), replaces the original sheet including Fig. 7(a) and 7(b). In Figures 4, 5, 6(a) and 7(b), previously omitted ground plane (element 54) has been added.

Attachment: Three Replacement Sheets

Three Annotated Sheets Showing Changes

input transmission line being ~~separate~~ separated by a gap from said output transmission line along a direction of propagation of said microwave and millimeter wave signals;

[4] Arguments for Claims Rejected Under *35 U.S.C. §112*

Please allow Claims 7-13 of the present application, which are rejected by the examiner under *35 U.S.C 112* as failing to comply with the enablement requirement, based on the following amendments made to the specification and to Figs. 4-7:

After the amendments to Fig. 6(a), a conducting film (54) as the ground plane of the switch (50) is no longer missing.

In Fig. 6(a), the previous missing label for recess region (68) is added and a description sentence for all elements depicted in element (50) including (68) is added.

[5] Arguments for Claims Rejected Under *35 USC§103*

Please allow Claims 7-13 of the present application, which are rejected by the examiner under 35 U.S.C 112 as being unpatentable over the Admitted Prior Art (APA), in view of US Patent No. 6,529,093 to Ma, based on the following rounds:

***Claim 7*:**

In Ma's invention, an **intermediate actuation electrode (507)** is disclosed to achieve **two-step activation** of the cantilever for the purpose of higher switching speed [column 4, lines 30-34]. This intermediate actuation electrode (**507**) has a height smaller than that of the anchor (**513**) and larger than that of the transmission line (**505**) [column 3, lines 62-65]. To actuate the switch (**501**), DC actuation voltages are applied both between the

cantilever (**503**) and the intermediate actuation electrode (**507**) and between the cantilever (**503**) and the transmission line (**505**) [column 4, lines 4-9]**.** During operation, the cantilever will be pulled down first to touch the intermediate actuation electrode (**507**) before it eventually make contact with the transmission line (**505**). Therefore, the intermediate actuation electrode (**507**) is there to achieve the first step activation of the two-step activation. <u>In this two-step activation, the cantilever (503) moves in the same "**downwards**" direction to turn "On" the switch (501)</u>.

In the present application, the third actuation electrode (**81**) in element (**80**) is disclosed as a <u>de-actuation electrode</u>. It serves an ***opposite*** role from that of <u>Ma's intermediate actuation electrode (507)</u>. First of all, the third actuation electrode (**81**) plays **no** role in turning "On" the switch (**50**), which is achieved by pulling down the cantilever (**58**) to be in contact with the output transmission line (**53**)**,** through an actuation voltage applied between the first actuation electrode (**60**) and the second actuation electrode (**61**). The de-actuation function of the third actuation electrode (**81**) in the present application is to <u>cause the cantilever (58) to move "**upwards**"</u>, so that the switch (**50**) can be turned "Off" with an extra help other than simply relying on the spring force of the cantilever to return to the "Off" state.

The third actuation electrode (**81**) is especially useful when the cantilever (**58**) is stuck on the output transmission line (**53**) after the "On" state and it can not be turned "Off" by simply switching off the actuation DC voltage between the first actuation electrode (**60**) and the second actuation electrode (**61**). When a DC **de-actuation voltage** is applied between the second actuation electrode (**61**) and the third actuation electrode (**81**), an attraction force is induced between the actuation electrode (**81**) and the cantilever (**58**). If the de-actuation voltage is sufficiently high, the cantilever (**58**) will be attracted toward the third actuation electrode (**81**) and to break free from the contact with the output transmission line (**53**). As a result, switch (**50**) will be turned "Off". The third actuation

electrode (**81**) also can be used to simply increase "Off" state isolation by increasing the gap between the cantilever (**58**) and the output transmission line (**53**).

In summary, Ma's intermediate actuation electrode (**507**) and the third actuation electrode (**81**) in the present application serve completely different functions: actuation vs. de-actuation. While the former is to achieve the first step of the two-step actuation of the cantilever, the later is to de-actuate the cantilever. In other words, Ma's intermediate actuation electrode (**507**) plays a part in the **"On"** activation process of the switch and the third actuation electrode (**81**) in the present invention only takes part in the **"Off"** activation process. **Physically**, an actuation voltage to Ma's intermediate actuation electrode (**507**) will move cantilever **downward** and a de-actuation voltage to the third actuation electrode **81** in the present invention will result in an **upward** movement of the cantilever. Therefore, based on the above-stated facts, it would **not** have been obvious to one of ordinary skill in the art to have applied Ma's teachings to APA's MEMS switch.

***Claim 8*:**

After carefully viewing the drawings in the present application, the applicants conclude that APA's actuation bottom electrodes (**18** and **19**) as depicted in Figure 1(b) of the present application are having the same thickness as that of the transmission lines (**3** and **4**).

In APA's switch (**1**), due to a limited freedom of the membrane bridge structure (**two anchors** instead of **one anchor** in a cantilever structure), the thickness of the contact pad (**6**), and the relative location of the actuation bottom electrodes (**18** and **19**) and the transmission lines (**3** and **4**), when activated, the center of the membrane will bend down so that the contact pad (**6**) underneath will always touch the transmission lines (**3** and **4**) first. In other words, the actuation bottom electrodes (**18** and **19**) will not interfere with the movement of the membrane bridge. Therefore, the thickness of the two actuation

bottom electrodes (**18** and **19**) **need not** to be smaller than that of the transmission lines (**3** and **4**) in APA's structure.

Due to a much larger freedom of the cantilever (**58**) in the present application, the first bottom electrode (**60**) with a larger thickness may prevent the cantilever (**58**) to make a good contact with the output transmission line (**53**). Hence, unlike APA's bridge membrane switch, a thickness restriction is required for the first bottom electrode (**60**) in the present switch (**50**).

Since in Ma's switch (**501**), the thickness of the intermediate actuation electrode (**507**) is **larger** (not smaller) than the thickness of the transmission line (**505**), Claim 8 is not obvious to one of ordinary skill in the art from APA and/or Ma.

Claim 10:

Please allow Claim 10 based on the following grounds:

1) Switch Structure Distinctions

Lack of a de-actuation function in Ma's and/or APA's switches

One most important feature in the present switch is the **de-actuation function** of the cantilever (**58**) through a third actuation electrode (**81**). This de-actuation function is missing from both Ma's and APA's switches.

Other major structure differences in Ma's and the present switch

Other than lack of a de-actuation feature, there is other structure deviation between Ma's switch and the present switch. In the present application, the cantilever (**58**) ***is directly connected*** to the input transmission line (**52**) and is a part of the signal transmitting path when switch is turned "On". Without the activation of the cantilever (**58**), the input transmission line (**52**) and output transmission line (**53**) are separated by a gap (**55**) and no signal can pass from the input transmission line (**52**) to the output transmission line

(**53**). Therefore, the switch (**50**) selectively connects the input transmission line (**52**) to the output transmission line (**53**) through the activation of the cantilever (**58**).

Unlike the present application, the cantilever (**501**) in Ma's switch is not a part of the transmission line (**505**). Without the activation of the cantilever (**501**), the cantilever (**501**) is not connected to the transmission line (**505**) and so is any circuitry connected to the cantilever (**501**) [column 4, lines 31-35]. Only when the cantilever is activated, a ***capacitive coupling*** between the cantilever (**501**) and the transmission line (**505**) is achieved through the dielectric layer (**509**) on top the transmission line (**505**), and the switch selectively connects the transmission line (**505**) to other circuit device through the activation of the cantilever (**501**).

2) Different coverage and function of the dielectric layers

In Ma's switch, dielectric layers (**509** and **511**) cover the **transmission line** (**505**) and the **intermediate actuation electrode** (**507**) respectively. The dielectric layer (**509**) is also needed to serve the purpose of a ***capacitive coupling*** between the cantilever (**501**) and the transmission line (**505**).

In the present application, the dielectric layers (**67, 85**) coat the first actuation electrode (**60**) and the third **de-actuation** electrodes (**81**) and there is **no** dielectric layer to cover the transmission lines (**52, 53**).

3) Insulation between activation electrodes is the core element of the electrostatic switch

Finally, in electrostatic MEMS switches, an electrostatic force is the foundation of the operation principle. In order to maintain a sufficient electrostatic force between two closely positioned conductors (in this case the two actuation electrodes when activated), an insulating element between the two, either in the form of an insulator or an air gap, is crucial. In other words, without this insulating element, no electrostatic MEMS switch

can function. In majority of the MEMS switches, an insulator (either a layer or a beam) is applied to ensure insulation between the two actuation electrodes. Therefore, using of an insulating layer on the actuation electrodes should be regarded as part of the operating principle of the electrostatic MEMS switches and should not be used as evidence for anticipation.

In conclusion, due to the two major distinctions presented in Ma's and the present switch, also in view of the different location and functions of Ma's dielectric layers, as well as the argument presented in the previous paragraph, Claim 10, as a dependent Claim of independent Claim 6 would not be obvious to a person having ordinary skill in the art.

Claim 11:

The examiner points out that APA's actuation lines (**20**, **21**) inherently have sheet resistances greater than the characteristic impedance of APA's transmission lines (**3**, **4**). However, in the applicants' opinion such condition is not requisite in APA's switch. By viewing Figure 1(b), it is clear that the APA's actuation bottom electrodes (**18**, **19**) and the bottom actuation lines (**20**, **21**) are **not** connected to **nor** in close proximity to either the input or the output transmission lines (**3**, **4**) (Figure 1(a)). When the membrane is activated to bend down until contact pad (**6**) is in touch with the transmission lines (**3**, **4**), the actuation lines (**20**, **21**) will not interfere with the propagating microwave signals. Similarly, the two actuation top electrode (**10**, **11**) are also separated from the contact pad (**6**) by two insulating inner supports (**8**, **9**) so that the propagating microwave signals along the input transmission line (**3**) and the output transmission line (**4**) when the switch is actuated will not be affected by the presence of the actuation top electrodes (**10**, **11**). Therefore, it is not required to have a sheet resistance for the bottom actuation lines (**20**, **21**) to be greater than the characteristic impedance of APA's transmission lines.

However, that is not the case for the switch disclosed in the present application. In the switch (**50**), the first, second actuation electrodes (**60**, **61**) and the third de-actuation

electrode (**81**) are all made of resistive lines. While the second actuation electrode (**61**) is directly connected to the input transmission line (**52**), the first actuation electrode (**60**) and the third de-actuation electrode (**81**) will come very close to the cantilever (**58**), when actuated or de-actuated (Please keep in mind that the cantilever (**58**) is also attached to the input transmission line (**52**)). Only when the sheet resistance of the first and second actuation electrode lines (**64, 65**) and the third de-actuation electrode line (**83**), especially (**64, 65**), is substantially greater than the characteristic impedance of the input transmission line (**52**) and the output transmission line (**53**), the effect of interference on the propagating microwave signals due to the presence of these actuation electrodes (**60, 61, 81**) and actuation electrode lines (**64, 65, 83**) could be minimized.

Based on the locations of the actuation electrodes and their link to the transmission lines in APA's and in the present switch, Claim 11, as a dependent Claim of independent Claim 6 would not be obvious to a person having ordinary skill in the art.

Claim 12:

In the present switch, the cantilever (**58**) is directly connected to the input transmission line (**52**) and when activated will directly connect to the output transmission line (**53**) and become a part of the signal propagating path. Therefore, the cantilever (**58**) is required to be conductive and to have the same line width as the transmission lines (**52, 53**) so that effect of interference on the propagating microwave signals due to the presence of the cantilever (**58**) will be minimized. Furthermore, unlike Ma's or all the other switches disclosed in the listed pertinent references, the cantilever in the present application does not have an anchor (e.g. **518**, in Ma). In the present application, the suspended portion of the cantilever (**58**) is not only connected to the input transmission line (**52**) through an inclined portion. It is also supported by this inclined portion. Because of the requirements (conducting and strength), cantilevers with both **a single metal layer structure** and **multiple layer structures** (to enhance the mechanical strength) with at least one metallic layer are disclosed in the present application.

Although Ma suggested three possible alternative materials for conductive cantilever beam in the specification, the only material proclaimed in Ma's invention is **polysilicon** [Claims 2 and 12]. Ma also failed to describe multiple layer structures of the metal cantilevers. Therefore, it is reasonable to state that Claim 12 of the present application would not be obvious to a person having ordinary skill in the art.

The applicants hope that the above-described amendment is acceptable to you and respectfully request that a timely Notice of Allowance be issues in this case.

Respectfully submitted,

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Attachments

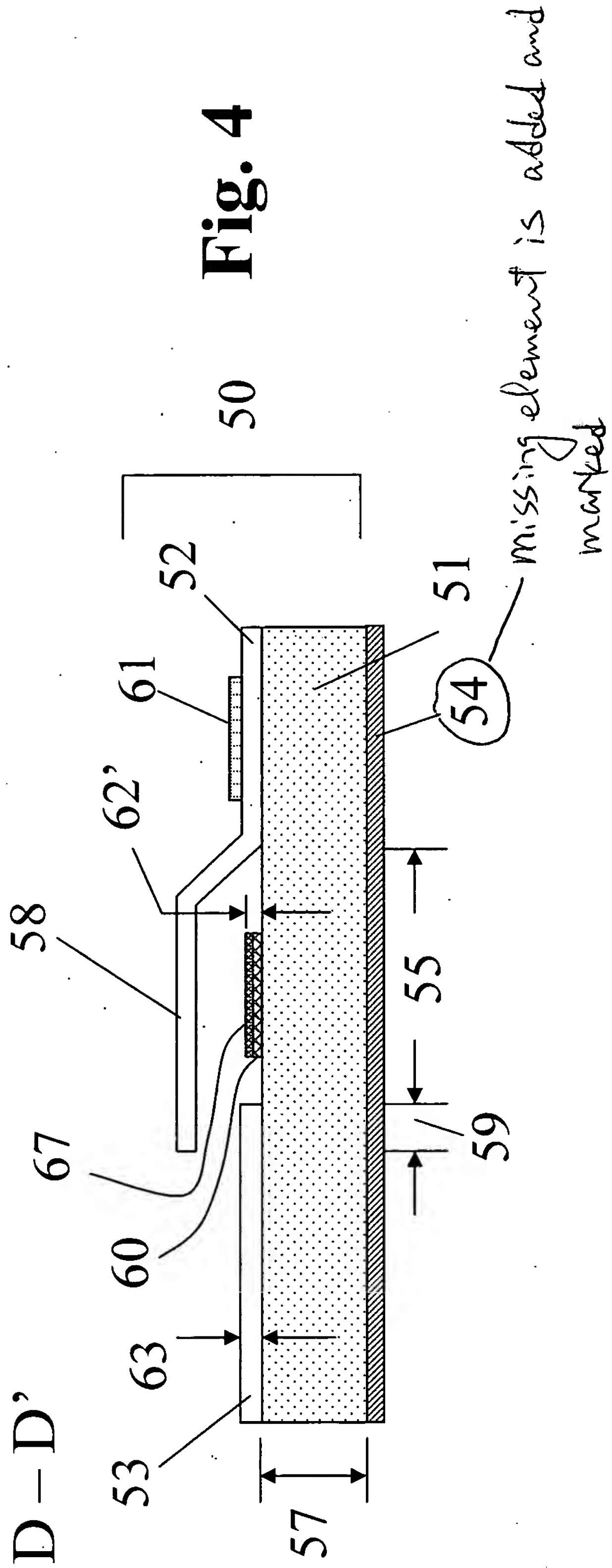
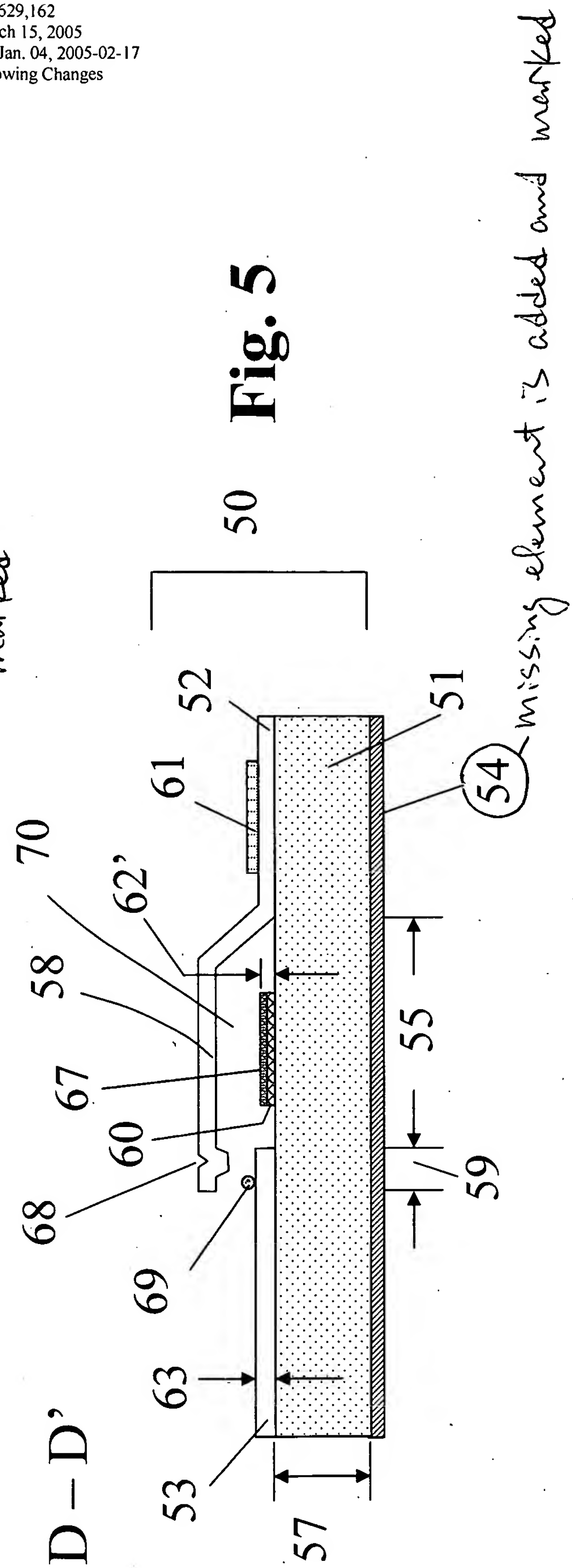

D – D'
50
52
61
62'
58
67
60
63
53
57
55
59
51
54
missing element is added and marked

Fig. 4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50
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61
70
62'
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67
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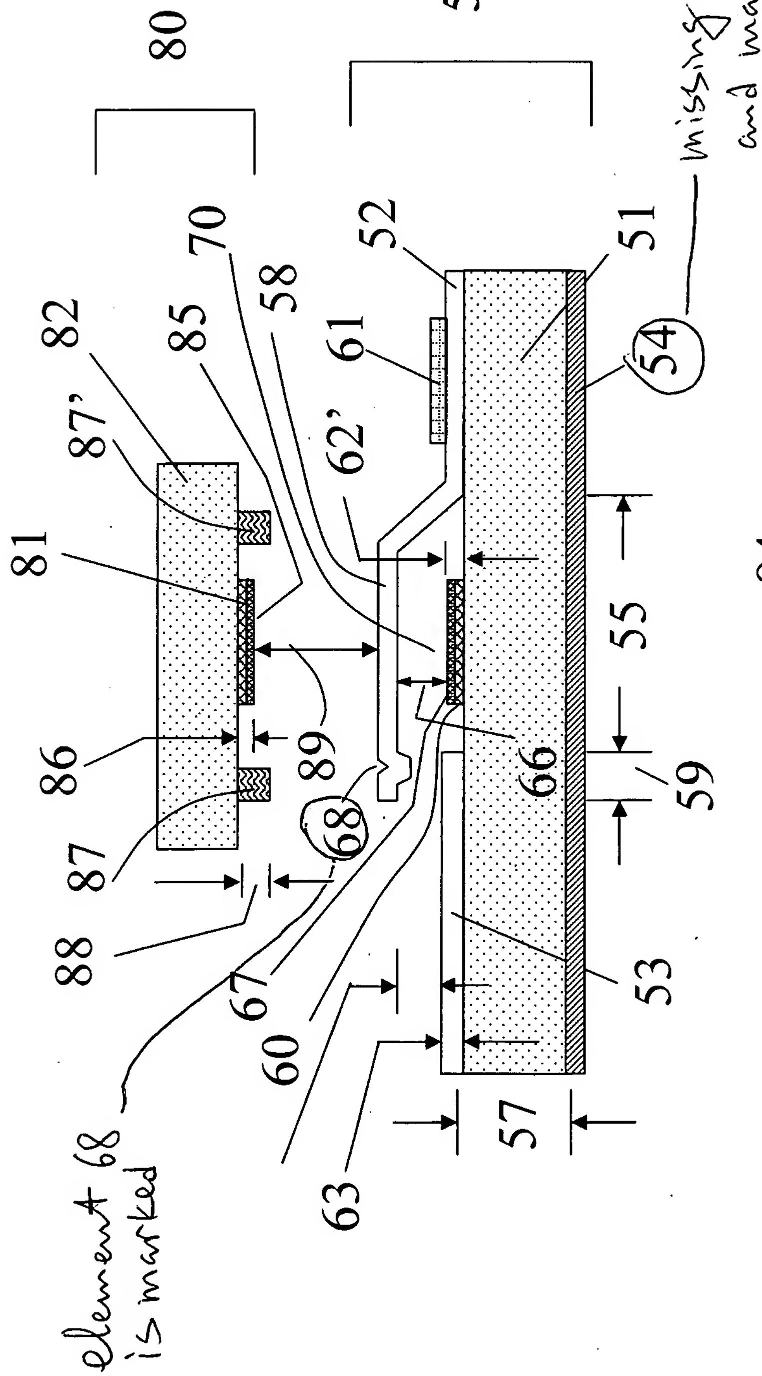
68
69
63
53
57
55
59
51
54
missing element is added and marked

Fig. 5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87'
81
85
70
58
52
61
62'
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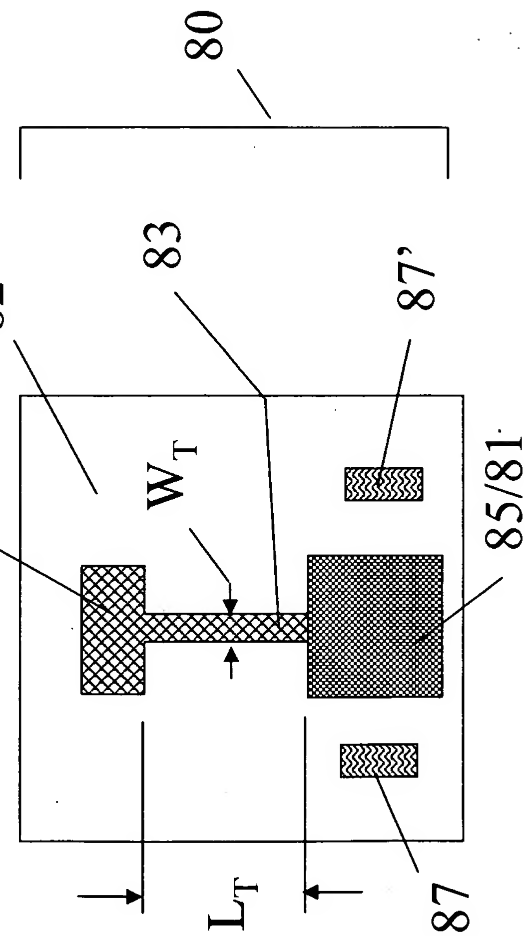
54
86
89
66
55
59
87
68
88
67
60
53
63
57
missing element is added and marked.
element 68 is marked

Fig. 6(a)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83
87'
84
W_T
85/81
L_T
87

Fig. 6(b)

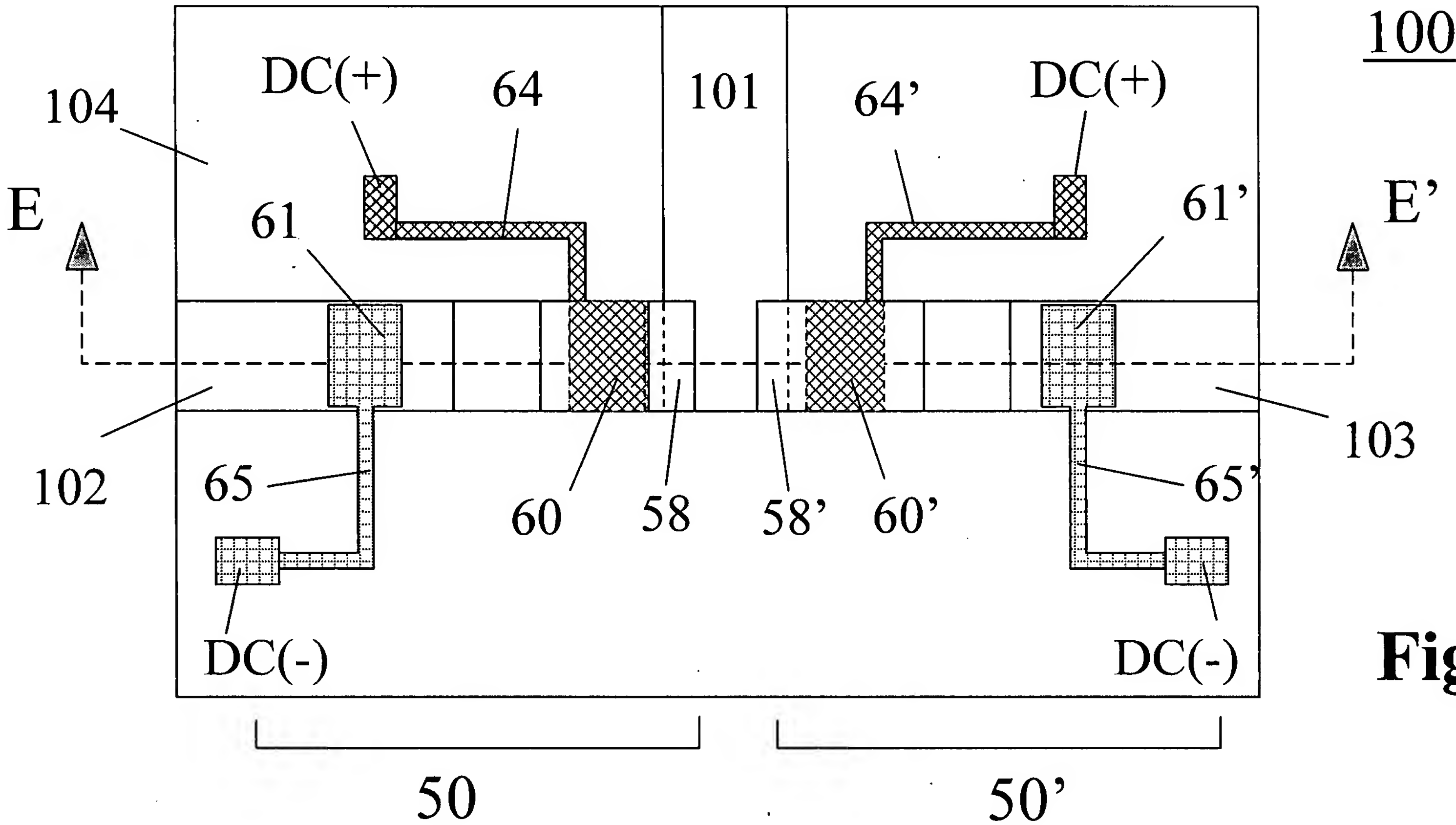

Fig. 7(a)

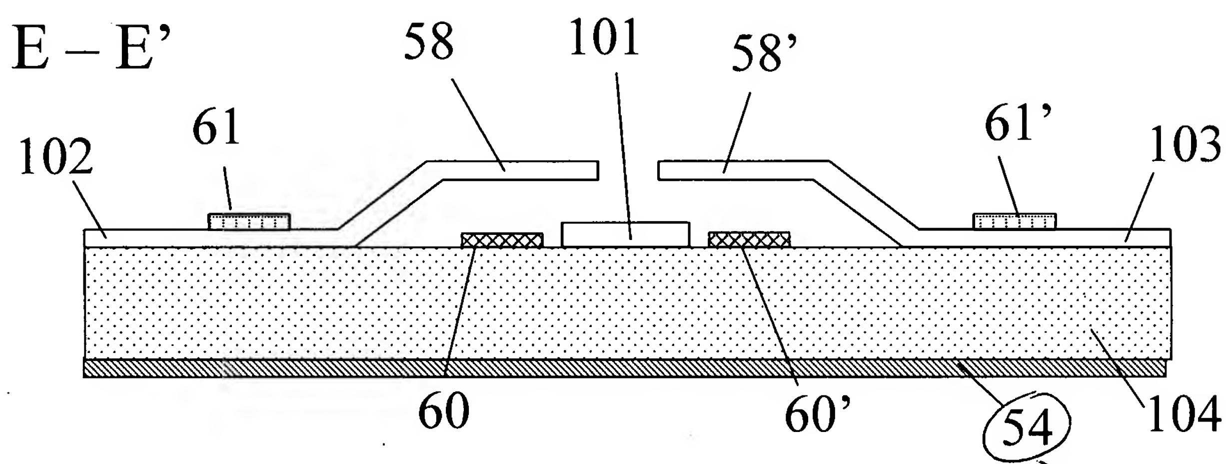

Fig. 7(b)

missing element is added and marked